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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXVII, No. 7 SEPTEMBER, 1933 WHOLE No. 226

Articles

PAGE

The Study of the Solar Corona without an Eclipse (with Plate V) *Bernhard Lyot* 265
Progress on the David Dunlap Observatory (with Plates VI and VII) - - - - - *C. A. Chant* 281
The Delusions of an Amateur - - *E. M. Antoniadi* 285
The Pacific Science Congress - - *W. E. Harper* 293
The Counterglow - - - - *E. G. Hogg* 298

News and Comments

General—Notes from the Dominion Observatory - *REDeL* 302

Notes and Queries

Seeing the Southern Cross—Luminous Night Clouds—Unpublished Observations on Variable Stars—A New Zeiss Catalogue *C.A.C.* 305

Meetings of the Society

At Ottawa—At Victoria - - - - - - - 309

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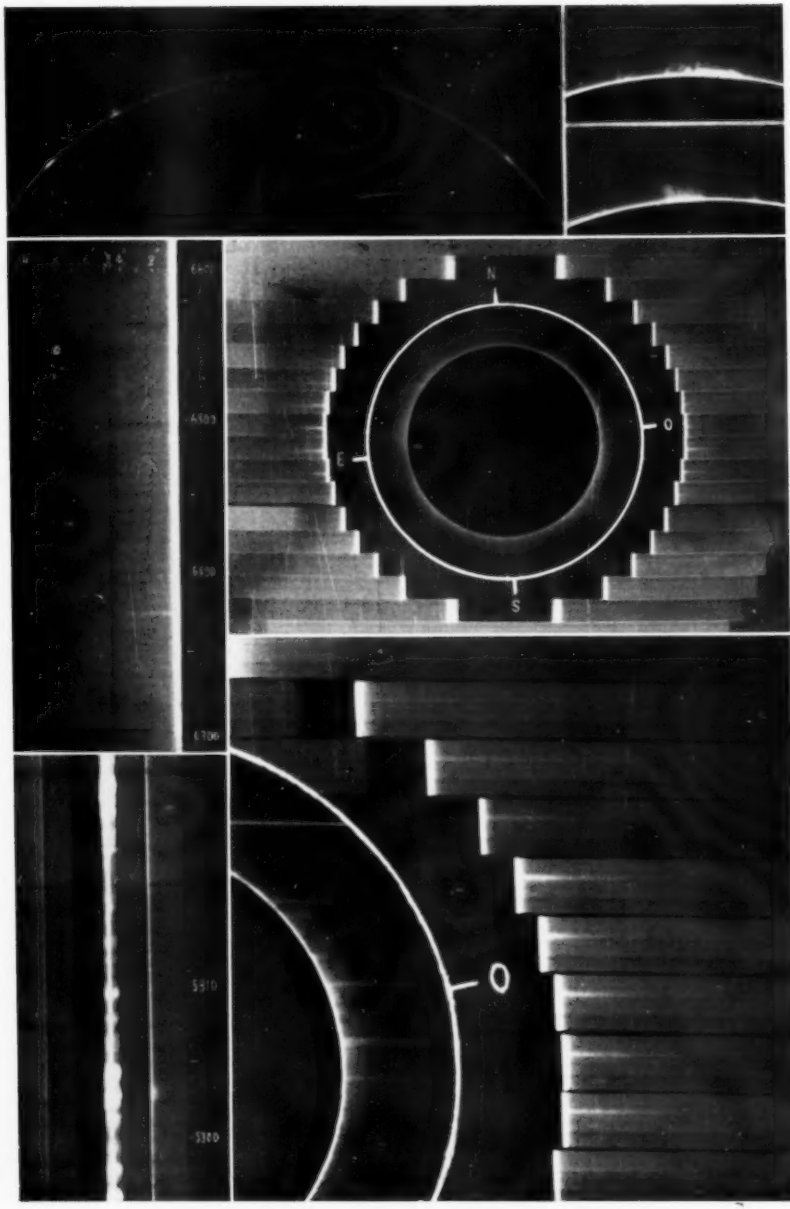
PLATE V



PHOTOGRAPHY OF THE CORONA WITHOUT AN ECLIPSE

Results obtained with Dr. Lyot's coronagraph and spectrograph during 1931. A, B, and C.—Prominences photographed July 18, 20, and 30. D (central part)—The solar corona photographed July 21. D (outer part)—Spectrographic sections of the corona. E (central part)—Portion of a monochromatic image obtained August 7. E (outer part)—Portion of a sectional photograph obtained on the same day. F.—The green line, August 7. G.—The red line, August 27.

Journal of the Royal Astronomical Society of Canada, 1933.

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THE STUDY OF THE SOLAR CORONA WITHOUT AN ECLIPSE

By Bernhard Lyot

(Concluded from page 234)

Second Paper

LAST year I had the pleasure of showing you the results of a preliminary series of experiments made at the observatory of Pic du Midi, during the months of July and August, 1930. These experiments permitted me to study the polarization of the inner corona and to photograph two bright lines of its spectrum.

On June 12, 1931, I returned to the Pic with better perfected apparatus and much more elaborate spectroscopic instruments. I remained there until the beginning of September, to try to photograph the corona directly and to record it with the spectroheliograph.

The photography of the corona at any time, without waiting for the rare occurrence of a total eclipse, is an important problem whose solution has been sought in vain, during a half-century, by a great number of astronomers and physicists (*Bulletin astronomique*, 1931, p. 305).

We shall first examine the difficulties which are encountered in this type of research: the diffusion of the rays of the sun by our atmosphere and by the particles which it holds in suspension, and by the instruments employed; we shall then describe the instruments which were used for this second series of experiments, and the results which they permitted us to obtain.

Atmospheric Diffusion.—The inner portions of the corona are bright enough; at distances between 1′ and 4′ from the solar limb, the brightness of the corona, otherwise called the intensity per unit of apparent area, is very nearly a millionth of that of the sun, or the average of that of the full moon. This brightness is practically equal to that of the planet Mars; it is also very nearly the same as that of our atmosphere, in good weather, when the sun is very high. Therefore it seems that one should be able to observe the corona easily, as one can observe Mars in broad daylight; our atmosphere should veil only the details, as it veils those of Mars, without making it disappear. Moreover, if a red filter is used, the brightness of the atmosphere is reduced, as compared with that of the corona, in the inverse ratio of the fourth power of the wavelength. With infra-red sensitive plates and an appropriate filter, then, it seems that it should be possible to photograph the inner corona almost on a black background.

Unfortunately, as far as the corona is concerned, there is a very important difficulty encountered in the immediate vicinity of the sun; the solar image produced by the objective or the mirror of a telescope is surrounded by a halo of light whose brightness often surpasses that of the corona a thousand times, and which obviously prohibits all observation. This halo is due to two effects: the diffusion of the light of the sun by the particles in suspension in our atmosphere, and the diffusion by the instrument of observation.

Diffusion by Particles.—Obviously, a perfectly pure sky is an extremely rare thing. To illustrate, choose a very beautiful day and hide the sun behind a screen at some distance from the eye—the top of a house, for example. It is certain that the sky, whose general colour is rather dark blue, will be whiter and brighter as the limb of the sun is approached. This increase is sometimes very abrupt, at other times very slow, but it is always very much more considerable than it appears at first glance.

During the last summer I often measured the brightness of the sky 20′ from the limb of the sun, through a red filter. At Meudon and in western France, in good weather, its brightness is in general several hundreds of times greater than that of the atmosphere. The least values, of 20 to 30 times the atmospheric brightness, were

observed only on three occasions, and these are still at least three times too strong to permit the direct photographic detection of any traces of the corona.

This halo of light surrounding the sun is due to the diffraction of the solar rays by many dust particles or by the tiny water-droplets in suspension in the air. A very thin veil of fog or mist, sometimes completely invisible, is enough to produce it. When it is fair weather, these particles are few, and they light up the whole sky very little; the amount of light which they transmit to us is actually less than that of the atmosphere, but, instead of being distributed almost uniformly over the celestial vault, it is concentrated almost entirely in the directions about equal to that of the incident rays of the sun, a fact which makes it particularly difficult to observe the corona. The halo is less blue than the rest of the sky. Its brilliance, as compared with that of the corona, varies about in the inverse ratio of the square of the wave-length, so that the use of infra-red plates does not reduce it sufficiently.

However, on the summits of high mountains, when there is no fog or mist, and when the air has recently been purified, as by a snow fall for example, this cause of parasitic illumination disappears almost entirely. At Pic du Midi, the brightness of the sky near the limb of the sun sometimes becomes less than twice that of the corona, which therefore, under the best conditions, should be observed.

Unfortunately, there still remains the most important cause of parasitic illumination—instrumental diffusion.

Instrumental Diffusion.—When a telescope is pointed at the corona, it is indeed practically impossible to shelter it from the light of the sun which illuminates the objective or the mirror in a direction very close to that in which one is observing. A small fraction of this light is diffused by the optical parts and forms a halo about the image of the sun, very faint as compared with the sun, but very intense as compared with the corona. Under ordinary conditions, its brightness easily amounts to a thousand times that of the inner corona. With a simple lens it is less great, but still very considerable.

For example, let the image of a bright source of light as formed

by a simple lens fall on an opaque screen so that the image can be seen clearly on the screen. If we place the eye or a small magnifier behind one edge of the screen, we see exactly what causes diffuse light. Fig. 3 is the reproduction of a plate taken in this way, the experiment employing a simple lens of 8 cms. aperture and 0.6 cms. thickness. The lens is far from being dark to the sight.

First, its edge is strongly illuminated by diffraction; the edge appears black because of photographic reversal, and there is a large diffusion halo about it, on the plate.

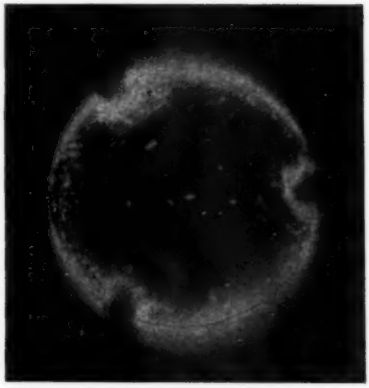


Fig. 3. Parasitic light diffused by a simple lens.

Second, we see the parallel bright streaks due to the flaws present in the glass; although they are very insignificant, the diffraction from them is an objectionable illumination.

Third, the lens appears to be covered with luminous points due to the diffraction of the incident beam by a little air bubble inside the glass, by the tiny scratches in the surface, and by the tiny particles on them. These defects appear even in the central portion, although it was polished and cleaned with the greatest care.

Fourth, the centre of the lens is occupied by a bright spot; this spot is an image of the source, produced by reflection between the two faces of the lens.

Any one of these sources of parasitic light shown on the plate alone would suffice to hide the corona entirely. An objective composed of several lenses, or the mirror of a telescope, shows much more diffuse light.

Coronograph.—I have sought to design a coronograph which will eliminate all these parasitic sources of light. The principal part of the instrument is a plano-convex lens of 13 cms. aperture and 3.15 metres focal length. It was figured at l'Institut d'Optique from Parra-Mantois optical glass, specially selected. It was ground and polished with the greatest care, and it has no flaws, bubbles, or streaks or scratches in the surface, in the central portion, for the better half of its diameter. In Fig. 4, this lens is placed at A, and forms an image of the sun on a disc B, of blackened brass, which

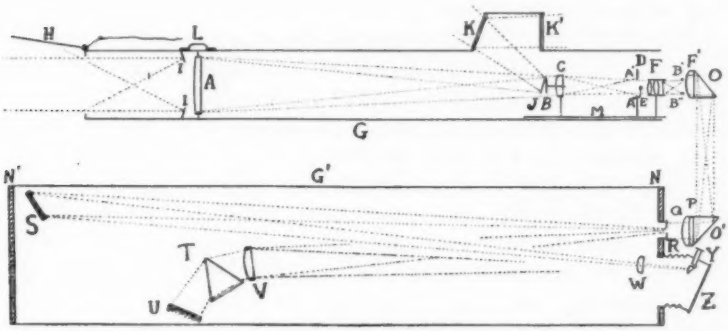


Fig. 4. Plan of the mounting of the coronograph (above) and the spectrograph.

extends beyond the edge of the sun by only fifteen seconds of arc. A field lens C, placed behind the disc, produces an image of the lens A at A′A″, on a diaphragm D, whose centre is occupied by a tiny screen E. The outer portion of the diaphragm stops the diffracted light from the borders of the first lens; the little screen E stops the light of the solar image formed by reflections between the two surfaces of the lens A. Behind the diaphragm and the screen, sheltered from diffuse light, an objective F, highly corrected, forms at B′B″ an achromatic image of the corona. These parts of the apparatus are mounted on a plate M which slides in grooves,

in order to permit the placing of any point of the solar image on the screen.

All the optical parts are contained in the wooden tube G, 5 metres long, whose inside walls are coated with heavy oil; the tube is closed by means of a cover H, which is opened only during the actual observations, and the lens A and its mounting completely close the tube, in order to eliminate air currents. Thus the lenses are suitably protected against dust particles.

The lid H is plated with brass; a concave diaphragm I and a disk J, likewise plated, send back the part of the radiation which is not used, in order not to stir up the air in the tube of the coronograph, a thing which is likely to lead to disturbance of the images. The radiation reflected by the diaphragm I all comes out again at the mouth of the tube; that which is reflected by the disc J comes out at the windows K and K'.

In spite of all these precautions, the cleanness of the lens A should be maintained, and, while it is a delicate operation, it should be attended to quite often. To take the lens from the tube, it is necessary only to lift up the cover L, to which the mounting of the lens is fastened. The dust particles are removed by wiping the surfaces, always in the same direction, with clean cotton, and constantly blowing across the surfaces in order that the electrification of the glass will not attract and hold the particles of the surrounding air. It is necessary to work rapidly, and to replace the lens in the tube immediately afterwards.

Choice of a Station.—In order to obtain from the coronograph all the results which might reasonably be expected, it was necessary to mount it in a place where the air is sufficiently often free from dust particles, and where it would be possible to use a very rigid equatorial mounting. From these two points of view, the observatory of Pic du Midi possesses great advantages; on the other hand, last June the snow was very abundant, and made it difficult to transport pieces of apparatus of large size. The various pieces of the coronagraph were designed and tested in the laboratory, at the Observatory of Meudon, but it was necessary to build the tube and to do all the mounting in position at the Observatory of Pic du Midi. The same procedure was followed for the spectrographs and

the spectroheliograph, of which only the optical parts with their mountings, and the delicate mechanical pieces, were taken to the mountain.

All this material, reduced to a minimum, was divided up into 14 packages, each weighing only about 15 kilograms (about 33 pounds). These packages were carried on men's backs from the village of Gripp, which is at an altitude of 1,000 metres, up to the observatory, at 2,870 metres. The snow comes down as far as 1,500 metres, and it covered a little more than half of the journey.

Prominences.—The coronagraph was fastened along the tube of the equatorial. Equipped with an eyepiece and a red screen, it showed, in spite of mediocre atmospheric transparency, many prominences, the smallest measuring only a few seconds in height. Fig. A of Plate V shows a picture obtained July 18, 1931, at 10 a.m., simply by placing a camera behind the eyepiece. The disc hiding the image of the sun appears bordered by a bright narrow fringe which is due partly to a phenomenon of secondary diffraction, partly to the vibration of the image.

When the images were very calm, it was possible to point the instrument very exactly, and to make the chromosphere appear as a very sharp line, largely composed of monochromatic light. Beneath a prominence, the chromosphere showed a slightly greater thickness than at other points of its circumference. When the disc exactly hid it, it remained visible under the prominences, so that they appeared mounted on a short and very bright line. The appearance is only guessed at on the plate, as it was very plain to the eye and very difficult to photograph.

Figures B and C of Plate V show two prominences photographed with exposures of two seconds, and an aperture ratio of 1/90; the first, on July 10, 1931, at noon, was in position angle approximately 295 degrees, and the second, on July 30, 1931, at 8 a.m., was in about position angle 60 degrees. The exposures are much shorter than with a spectroheliograph. The optical system of the coronagraph being much less complicated, as well, it should be able to show clearer images; unfortunately, last summer, there was not a single exceptional prominence.

Direct Photography of the Corona.—I succeeded in photograph-

ing the corona directly in the month of July, 1931. The coronagraph was provided with a plate-holder which permitted taking 12 images on one plate 9 × 12. It was carried by two iron rings notched in such a way as to permit turning on its axis, between each two exposures, by fifteen degrees. The comparison of images thus obtained afterwards enabled one to distinguish the coronal details from the instrumental defects. In order to diminish diffusion, care was taken to use as long wave-length as possible, although the lack of contrast of far red and infra-red plates seemed to compensate for the advantages which their use ensured. These considerations induced me to use panchromatic plates for the exposures. A Wratten α filter was used with Guilleminot panchromatic plates, thus using the light of the continuous spectrum between 6,500 and 6,600 angstroms. The plates were developed completely, as denoted by a contrast detector.

The black disc of the coronagraph was covered, on the side towards the photographic plate, by a slightly smaller disc of white cardboard, illuminated obliquely by a bundle of solar rays. The brilliance of the light diffused by this disc was five millionths of that of the sun. Photographic exposures were made only when the brightness of the sky, as seen in the coronagraph, was equal to or less than that of this diffusing disc.

At 4 p.m., July 21, eleven exposures were made under conditions of exceptional atmospheric transparency; five of these, unfortunately, are of no value, but the other six show a little prominence in position angle 50 degrees, and three jets of light of which two are very plain. These details rotated, from one exposure to another, along with the prominence, in the opposite direction from that of the rotation of the coronagraph, and belong, consequently, to the corona. At the same time, some marks may be seen to remain the same for each exposure; most of these are due to the dust particles deposited on the second lens of the coronagraph.

The contrast of the images of the corona was increased by the following procedure: the negatives were successively projected, by means of an enlarging device, on a high-contrast plate, in exact superposition, as determined by a preliminary examination of the more readily distinguishable details. Let n be the number of

negatives, and γ the contrast factor of the positive plate. In the first approximation, the weak contrasts of the object photographed are multiplied by γ, while the statistical irregularities of distribution of the grains are multiplied only by $\gamma/\sqrt{n}$. The faint spots have their contrasts multiplied by γ/n, and if n is a little large they disappear. If n is great, it is best to eliminate the defects of the positive plate by printing several positives, and superimposing them, in their turn, to make a second negative. The final image should show details much fainter than any one of the negatives used, about in the inverse ratio of the square root of the number of images used.

The central part of Figure D, Plate V, is a reproduction, without retouching, of an image obtained in this way from the six negatives of July 21. In addition to the little prominence situated in position angle 50 degrees, this plate shows a faint bright fringe at the north pole, bracketed by two dark notches about 25 degrees apart, the one towards the northwest being the darker of the two. At the east, a streamer of bright light, well defined, extends from 30 to 95 degrees, and reaches to a height greater than 7′ from the limb of the sun. A second, narrower streamer, 4′ in height, appears from 110 to 135 degrees. The south limb is faintly luminous, but, at about 215 degrees, a luminous streak appears and attains its maximum intensity at about 260 degrees. It weakens rather suddenly a few degrees farther north, and ends at about 330 degrees, at the dark notch spoken of previously.

This image of the corona appears projected against a luminous background whose brightness is about four millionths of that of the sun. Only a quarter of this can be attributed to the diffusion of the atmosphere, and a still smaller amount to the diffusion by the few particles which were in the air at the time. The diffusion by the coronagraph is still the most serious, in spite of all the precautions taken; it amounts to a background of a brilliance of about two or three millionths of that of the sun. Further care will have to be taken to perfect the apparatus, principally to the end of eliminating more completely the dust particles which settle on the optical parts.

Spectrum of the Corona.—Nearly all the light of the corona is spread out in a continuous spectrum; the direct photography that

has been described and the measures of polarization whose results were published last year were obtained with the radiations of this spectrum.

The rest of the coronal light is divided up into several bright lines. These lines are very faint, but, as a compensation, the continuous spectrum of the diffuse light, against which they are projected, is very much weakened by the dispersion of the spectroscope. With sufficient dispersion, the observation of the brightest lines is easier to accomplish, without an eclipse, than is the direct photography of the corona or the study of its polarization.

On July 30, 1930, for the first time, I observed the spectrum of the corona by letting the image given by the coronagraph fall on the slit of a direct-vision spectroscope to which it is possible to attach a camera 30 centimetres long. In spite of its low dispersion, this instrument permitted me to see and to photograph the two strongest lines of the visible spectrum, the green line and the red line.

Apparatus.—In 1931 I designed more elaborate apparatus, with a greater coronagraph and spectrographs with much higher dispersions, of which one was transformable into a spectroheliograph. Fig. 4 shows the general design of the set-up.

The spectrographs are mounted inside the tube of the telescope, G′. This tube is 6 metres long; at its lower end the mirror cell was replaced by a wooden panel, N, which carries the slit and the plate-holder, which are common to both spectrographs; the upper opening of the tube is closed by a similar panel N′.

The achromatic objective, F, of the coronagraph was removed and replaced by a simple lens F′ which forms the image of the corona on the slit R of the spectrographs after passage through two totally-reflecting prisms O and O′. The second prism is followed by a coloured filter P, which isolates the spectral region to be studied, and a field lens Q. This lens forms the image of the diaphragm D either on the grating S or on the prism T, according to the orientation which is given the prism O′. The optical parts, O and F′ at one point and O′, P, and Q at the other, are bound together by castor oil, in order to decrease the loss of light.

One of the spectrographs has, as its dispersive unit, the grating S. This is a concave Rowland grating of 7 metres radius of curva-

ture and 14.5 centimetres of ruled surface; it is used in the second order and it forms an image of the spectrum on the photographic plate placed at Z. At W, the rays pass through a converging lens of 60 centimetres focal length; this lens corrects the strong astigmatism introduced by the grating; it reduces by a sixth the size of the spectrum, and it reduces the time of exposure as well, in the same proportion. This arrangement gives a dispersion of 1.2 angstroms per millimetre, but the image is not very bright.

The other spectrograph uses an excellent 61-degree flint-glass prism T, the base of which measures 15 centimetres; the prism is traversed twice, the light being reflected by a plane mirror U and passing twice through a simple lens V, of 3.60 metres focal length. This arrangement gives excellent images, with a dispersion of 3 angstroms per millimetre in the green, the exposure times being only one fifteenth as long as those necessary with the grating. When the prism is used, it is necessary to take away the lens W.

The tube of the telescope undergoes variable flexures, according to its position, and the spectral lines are constantly shifting. The observer must correct these displacements during the entire duration of the exposure. For this purpose, by means of a microscope Y mounted at the plate-holder, he follows a monochromatic image of a little aperture near the slit R of the spectrographs, illuminated constantly by an iron arc.

The prism spectrograph can easily be changed into a spectro-heliograph by installing, in front of the plate, a second slit which isolates a line or a portion of the spectrum. The displacement of the image of the corona is effected by turning the prism O about its axis. The displacement of the plate behind the second slit is accomplished by sliding the plate-holder in the slots provided at Z.

The coronagraph was mounted on the side of the tube of the telescope, by means of blocks and wedges. The prism was mounted on a triangular platform at the lower end of the coronagraph. This little platform is so mounted that it may be turned by means of a slow-motion screw, which is turned by a ratchet wheel driven by an electro-magnet.

The mirror cell of the telescope was removed, and its place was taken by the wooden panel carrying the slit, the second totally-

reflecting prism, the plate-holder (arranged to move in two rectangular coördinates by turning the proper screws), and the guiding eye-piece. The plate-holder is further equipped with a slow-motion screw which is actuated by a ratchet wheel and an electro-magnet, in parallel with the first one mentioned. These two electro-magnets are supplied by a contact wheel connected with the movement of the clock; their motion and speed of displacement may be regulated at will by the observer.

A second guiding telescope, near the first slit of the spectrograph, enables the observer to see an image of the disc masking the sun, surrounded by a coloured fringe. Thus the observer can employ the controls of the telescope to keep the sun accurately centred behind the disc. If the field should be crossed by thin clouds, the observer can press a key which stops the contact wheel and all the mechanism of the spectroheliograph, and closes the first slit, at the same time. During the entire duration of the exposure, a second observer actuates either a mercury or an iron arc, and corrects the displacements of the spectral lines. The panel is pierced by seven aluminum tubes, carrying flexible cables which permit the long-distance adjustment of all the parts of the two spectrographs. The upper end of the telescope tube is covered by a second wooden panel, already illustrated and spoken of. We shall now see what results have come from this apparatus.

The Green Line.—The outer part of Figure D, Plate V, shows a sectional print obtained with the spectroheliograph, July 22, from 9 a.m. to 12.10 p.m., with a series of 10-minute exposures. The image of the sun was 30 millimetres in diameter, on the original negative. The transparency of the sky was very good, but, unfortunately, the plate was fogged by light which leaked in from the side. The first slit was 5/100 mm. in width, the second was 2 mms., permitting the passage of a spectral region 10 angstroms long (equal to twice the separation of the D lines of sodium). The image of the corona and the photographic plate were displaced two millimetres each 10 minutes, in order to obtain an image of the green line around the entire circumference of the sun.

The solar lines are the same on each strip, if one takes into account the differences due to variations in intensity of the atmos-

pheric light from one exposure to the next. The bright line, on the other hand, varies considerably from one part of the corona to another. It reaches its maximum at the east, just above the equator; at the northeast, it can be traced as far as 9′ from the limb of the sun. It appears to suffer, at some points, some slight displacements corresponding to a very small radial velocity.

If this picture is compared with the direct photograph taken the preceding day, placed in the centre, it would appear that the green line is distributed about the sun very similarly to the continuous spectrum of the corona, but that it undergoes much stronger variations of intensity.

Figure E of Plate V shows, at the left, an enlarged portion of a monochromatic image obtained on August 7, from 11.40 a.m. to 1.15 p.m., by reducing the stroke of the electro-magnets and increasing the frequency of their actions. Both slits were 2/10 mm. in width, and they isolated a region of the spectrum 1 angstrom wide, containing the green line. The corona is very weak, showing only a fair arch towards the west, at the equator; this arch contained several slanting filaments similar to those observed in white light, during eclipse (photographed for the first time by Mitchell, during the eclipse of October 21, 1930, with an objective prism; this structure is therefore confirmed, in view of our two separate observations made under very different conditions and in all independence). Unfortunately, the image is crossed by white streaks due to the passage of very light clouds during the exposures.

The right-hand side of the same figure shows an enlarged portion of a sectional picture obtained the same day, from 2.45 to 6.10 p.m., with exposures of 10 minutes. We find the green line very strong at the point corresponding to the arch of the preceding photograph, and very faint throughout the rest of the corona. This arch was located above a group of spots and faculous regions, the only group of importance present on the disc of the sun. This figure, although not very greatly enlarged, shows the green line very wide; this width is not due to the spectrograph, for on the negative the line is measured as 0.9 angstrom wide, whereas the neighbouring triplet, of which the components are only 0.7 angstrom apart, is completely resolved. This width appears to better advantage in the spectrum

reproduced in Figure F, Plate V. This spectrum was obtained also on August 7, between 7.40 and 9.40 a.m., with the concave grating, the dispersion on the negative being 1.2 angstroms per millimetre. The slit, lying east-west, crossed the arch of Figure E. The spectrum was considerably narrowed by a cylindrical lens. In the centre appears a bright streak due to the iron arc; on each side of this there is the spectrum of the cardboard disc, bordered on each side by a diffraction fringe; at the extreme right and left appears the spectrum of the sky, consisting of the solar lines. At the bottom can be seen the triplet of the preceding illustration, spoken of earlier; one component appears as a quadruple line, the components being separated by only 2/10 angstrom. A bit higher, the bright green line appears, very strong at the west, very weak at the east; its total width is about 1.2 angstroms, as can be judged by the marks which indicate the wave-lengths in International angstroms. The tracing of the line, obtained with a microphotometer, is very regular and symmetrical, if we discount the effect produced by the line of iron in the sun, at 5302.309 angstroms.

The last three plates discussed were all taken on the same day, under conditions of very favourable sky, and they represent a total exposure time of 7 hours; if one adds to this the time necessary for changing the apparatus and for making the necessary adjustments, it may be seen that the corona was observable under the best conditions during more than 11 consecutive hours.

The intensity of the green line was measured by means of the microphotometer and compared with that of the continuous solar spectrum, by means of the diffusing disc spoken of under the heading *Direct Photography of the Corona*. The light of the line, near the limb of the sun, sometimes amounts to as much as 70 millionths of that of 1 angstrom of the continuous solar spectrum, and at other points it falls below 3 millionths.

These photographs permit a determination of the wave-length of the green line. Contrary to what one might expect, the spectrum as obtained from the grating gives no greater precision than that obtained with the prism; the accuracy is limited by the width of the line. On the other hand, by means of the sectional pictures a great number of images may be measured, and thus the probable error is

considerably decreased. The measures were made at Meudon, by Monsieur H. Grenat, who found for 36 images of the line a mean wave-length, in International angstroms, of 5302.83 at the east, and 5302.87 at the west, with a probable error of 3 or 4 hundredths of an angstrom. The difference between these two values, about 4/100 angstrom, is very uncertain; it corresponds to a rotation a little slower than that of the sun. The general mean wave-length, 5302.85, is determined with a precision superior to that obtainable at an eclipse, on a smaller number of plates taken with spectrographs necessarily less highly dispersive.

The Red Line.—The spectrum of the corona contains, in the red, another line, sometimes rather intense; its recording necessitates a much longer exposure than that of the green line, a fact which forbids the use of the grating.

From August 16 to 28, 1931, I obtained 7 spectra and 2 sectional pictures showing the red line with a dispersion of 11 angstroms per millimetre, and exposures from 30 minutes to 2 hours, 30 minutes. Figure G of Plate V shows a portion of one of these plates, taken on August 27, from 4 to 4.30 p.m., on a plate hypersensitized in ammonia. Near the bottom appears the bright red line at the eastern limb, and near the top the first line of the Balmer series of hydrogen, in absorption. The divisions marked at the right give the wave-lengths in International angstroms, and those at the top give the distances from the limb of the sun, expressed in minutes of arc.

On some of the plates, the line extends as far as 6 minutes from the limb of the sun; it seems wider than the Fraunhofer lines; with a higher dispersion its width would appear, without doubt, comparable with that of the green line. Its intensity amounts to about 20 millionths of that of 1 angstrom of the continuous solar spectrum; the sectional pictures show that this intensity is very variable from one point to another; the line has been recorded as far as the north pole of the sun. The red line appears to undergo deformations, from one image to another, which decrease the precision of the wave-length measures. These measures, made at Meudon by Monsieur H. Grenat on the four best plates, give 6,374.75 International angstroms, with a probable orror of 0.15 angstrom.

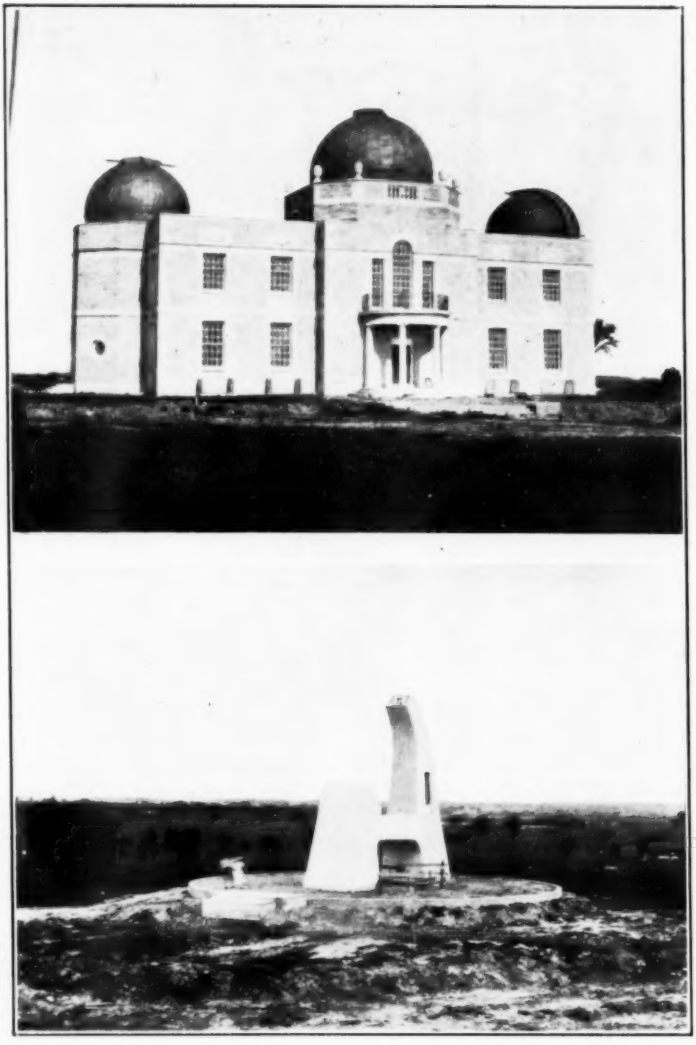
Other Radiations.—From August 10 to 12, 1931, I made as well

a series of spectrograms in the blue and violet with the prism and a dispersion of 2 angstroms per millimetre. These spectra were intended to record the coronal lines at 4232, 4086, and 3986, which are, in general, as intense as the red line. The lines did not appear. Attempts to show them on sectional photographs were likewise unsuccessful; apparently their intensities are less than 6 millionths of that of 1 angstrom of the solar spectrum. Plates taken at Meudon on the same days showed no region near the limb of the sun where the solar activity was of any importance.

The results which we have presented have been obtained when the solar activity is at a minimum. The observations which will be made on the corona at the next maximum will give, undoubtedly, very complete information.

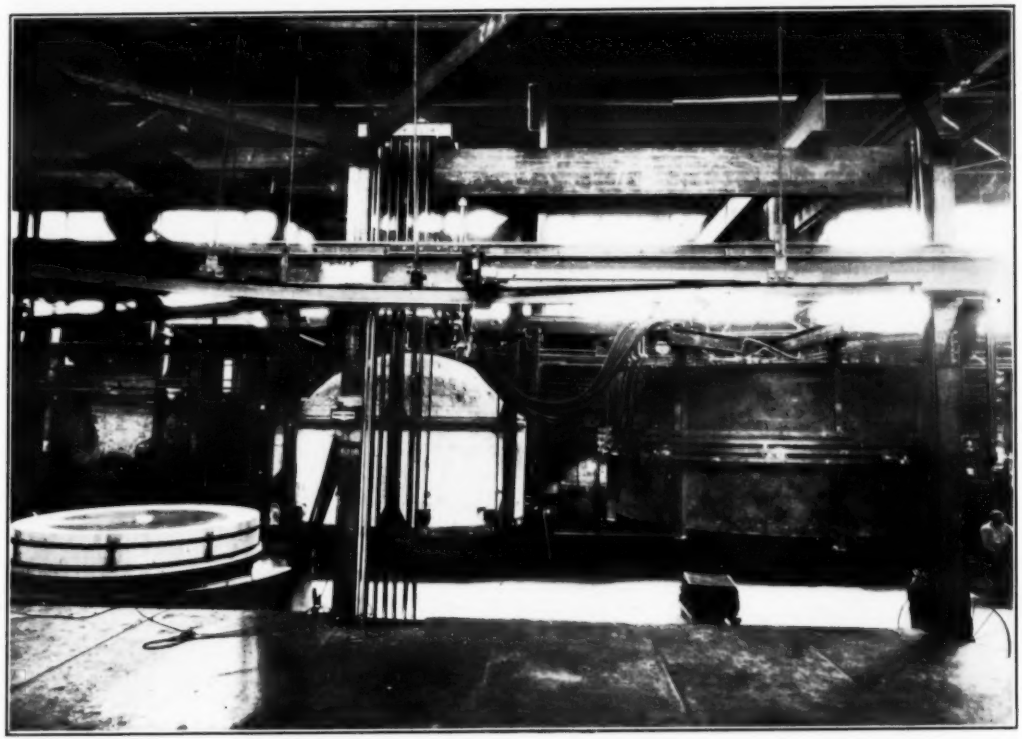
Hereafter we possess three methods of studying the corona at any time, and of following its progressive changes. Of these, the direct photography of the corona is at once the most difficult and the least productive of results, for the time being; the images are very inferior to those obtained at eclipses. Measures of polarization furnish a method better adapted to determination of the shape of the corona, by using the light of the continuous spectrum. The study of the bright lines, by means of the spectroscope and the spectroheliograph, is the most interesting method to be applied without an eclipse. Diffuse light increases the intensity of the continuous background upon which the bright lines are projected, but this increase is compensated for by the dispersion of the spectrograph, which weakens the continuous background without weakening the lines, which are almost monochromatic. The very leisurely fashion in which one may proceed when there is no eclipse permits the profitable application of all the advantages of the spectroheliograph, to study the shape of the corona, its motions, and the intensities of the lines, in a very much more accurate and complete way than is possible at an eclipse.

This work has been facilitated by the firm of Parra-Mantois, who furnished me two excellent discs of optical glass, by the Institut d'Optique, which was entrusted with the working of the lens of the coronograph, and by Monsieur Calzavarra, who obtained for me a series of especially sensitive plates. I am very happy to express to them my deepest appreciation.



THE DAVID DUNLAP OBSERVATORY

Above.—The Administration Building.
Below.—The pier for the great telescope and the foundation for its house.



A B C

IN THE CORNING GLASS WORKS

A, the disc for the 74-inch mirror of the David Dunlap Observatory in its mould (at about 600°C.)
B, the bee-hive covering which has just been removed from the mould.
C, the annealing oven in which the mirror was placed.

PROGRESS ON THE DAVID DUNLAP OBSERVATORY

By C. A. CHANT

(With plates VI and VII.)

THE Administration Building of the Observatory is practically finished. The lighting fixtures have yet to be put in and the electric service wires have to be brought to the building. During construction wires were carried on temporary poles so that power could be available for the various sub-contractors. Ultimately on the observatory property all the wires will be placed underground so that no disfiguring poles will be seen. During the summer many visitors driving along the great highway to the north have ventured up the half-mile roadway, although it has been in poor condition through the heavy trucking over it. An entirely new entrance to the grounds is to be built from the south. There has been general comment on the artistic design of the exterior of the building and on the beautiful and substantial manner in which the interior is finished. The furnishing of the building will be undertaken soon. A view of the west front of the building is shown in Plate VI.

The 19-inch reflector constructed by Professor R. K. Young and described in this JOURNAL (January, 1930), is in the south dome, but is not yet mounted. The last task performed by the contractor's steam hoist before it was dismantled was to raise this telescope to the roof. It is expected to be in use in the autumn. The refractor for the central dome and the photographic outfit for the north one will be provided later.

The cement foundation for the 61-foot circular building, which will house the 74-inch reflector, and also the massive pier for the instrument itself, have been ready for some weeks. A view of them as seen from an upper story north window of the Administration Building is shown in Plate VI. The strange-looking pier has elicited many odd conjectures and remarks from the visitors.

The steel building, with its revolving dome, was constructed in England and was shipped by steamer directly to Toronto, where it arrived on July 29. It is now being erected by a local contractor.

The great telescope (except the mirror) will arrive in Toronto about September 1 and will be erected at once. A representative of the firm of Sir Howard Grubb, Parsons and Co., which is supplying both telescope and building, will be on hand to supervise their erection.

Some delay has been experienced in obtaining the mirror. Extensive experimenting was carried out by the Parsons Optical Glass Co., in preparation for casting the big disc of glass, but after three years these efforts were abandoned, and a large English plate-glass firm offered to undertake the work. In the meantime, however, the labour on the production of a 200-inch quartz disc for the California Institute of Technology had been discontinued and the Corning Glass Works had begun the casting of large discs from their well-known Pyrex glass. A 30-inch and a 60-inch disc had been successfully made, and the company was ready to proceed with larger sizes. Now ordinary Pyrex glass has a much smaller coefficient of expansion than that of crown glass, the ratio being about 32 to 92, and hence it is much more desirable for a telescope mirror. The English contractors on learning of the successful production of these discs hesitated to proceed with a crown glass disc, although it could be obtained much more cheaply. They were anxious to supply a telescope of the very highest quality; and after some negotiations they gave the Corning Glass Works an order for a Pyrex disc. Still further research by this company enabled them to offer a material having a coefficient of expansion one-fourth less than that of ordinary Pyrex.

The disc was poured at Corning, N.Y., on June 21. At the invitation of the firm a party went by motor from Toronto to Corning (some 240 miles) to witness the operation. Those present were Mrs. D. A. Dunlap, the donor of the Observatory; Mrs. C. A. Chant; Professor R. K. Young; Mr. P. H. Mitchell, consulting engineer; Mr. F. Jno. Bell, the agent in Canada for the Grubb-Parsons firm; and the present writer.

I believe that usually in casting a large disc like this the sand and other ingredients are melted together in a furnace which is then tapped, and the liquid glass flows out into the mould. That method

was not followed at the Corning Glass Works. The melting furnace contained about 75 tons of glass, and it had taken five weeks to insure that it was of the proper consistency. The furnace was heated by gas and the maximum temperature attained was about 1600°C. The mould, which was constructed from refractory bricks, was about twenty feet away from the furnace. First, the scum was drawn from the surface of the glass in the furnace, then a large iron ladle capable of holding about 800 pounds was thrust through the furnace door, filled with glass and then carried by means of an overhead trolley to the mould. The door of the latter was drawn aside, the ladle pushed within and inverted. The viscous glass flowed from it and slowly flattened out in the mould, which was being maintained at a temperature of about 800°C. When about half of the contents had run out of the ladle, it was withdrawn and the balance of the glass in it was dumped on an iron plate from which it was drawn into a tub of water. This process was continued until the mould was filled, thirteen ladlefuls, or nearly two and a half tons in all, being required. The operation began at 5.30 a.m. and lasted two hours.

Each ladle of glass as it was poured into the mould could be seen spreading out over the previous ones. When sufficient glass had been poured in, the temperature was raised to 1250°C., and held there for about 4½ hours. This was done to bring the glass to a homogeneous consistency and also to cause any bubbles in it to rise to the top. Then the upper bee-hive covering was raised and the mould pushed aside into the open, revealing the tawny-red disc of glass. After allowing it to cool for four or five hours, until a temperature of 600°C. was reached, it was moved under the annealing oven into which it was raised (Plate VII). The temperature is controlled by electric currents and is being allowed to fall slowly. It is expected that by the middle of September the disc will be ready to ship to Newcaste-on-Tyne where it will be ground and polished.

The disc as cast is about 76½ inches in diameter and 12½ inches thick. The lower surface was cast concave and a 7-inch hole was cast in its centre. This will save much grinding away of material

in England. When finished the disc will have a diameter of 76 inches, a thickness of 12 inches at the edge and 11 at the centre.

I hesitate to predict when the mirror will be ready, but hope that there will be no unforeseen causes for delay and that it will be ready to be put in its mounting in one year.

THE DELUSIONS OF AN AMATEUR

By E. M. Antoniadi

A FEW weeks ago, I read in the English scientific review *Nature* that a person who is unknown to the astronomical world had started a controversy in your pages on my recent book on Mars. I replied forthwith, and my letter was published in the issue of June 3 of that great serial.

It is only yesterday that I saw on pages 66 to 74 of your *Journal* the article in question, which is characterized by the prejudice and presumption of someone utterly unacquainted with the most elementary rudiments of science; and it is the object of the present reply entirely to refute that paper, whose total lack of argumentation and glaring errors have no parallel in the annals of scientific discussion.

In my regard for the truth, I had called attention to the illusive nature of the linear canals believed to exist on Mars by the four transatlantic observers whose names are given on page 66; and I had exalted the work of Schiaparelli, as, in the places of his *canali*, the planet showed to me, in the large telescope, some irregular streaks, or some jagged edges of half-tone, or again some isolated dusky spot,—an attitude which has been enthusiastically received in Italy. As my contradictor does not shrink from stooping to personal matters, I unhesitatingly follow him on that ground also, declaring that his contribution to astronomy is negative, and that I would never exchange my work, rewarded by the highest prizes, for that of the four observers he is mentioning.

The same writer betrays his complete ignorance of the very

Note by the Editor.—Early in 1932 an article was received from H. Boyd Brydon in which he criticised the views regarding the "canals" on Mars expressed by M. Antoniadi in his book on that planet. Mr. Brydon was informed that the Editor was willing to print the article provided M. Antoniadi was given an opportunity to present a defence of his views and this would close the discussion. To this Mr. Brydon agreed. The article was then put in type and a proof of it was sent by post to M. Antoniadi on June 1, 1932. This proof, it would appear, was lost in the mails. After waiting some months without receiving any acknowledgment from M. Antoniadi, Mr. Brydon's article was printed in the February, 1933, issue. The Editor is pleased to provide space for M. Antoniadi's article.

conditions of planetary observation by questioning the fact so familiar to all beginners, that excellent definition is obtained on a hazy or foggy night. "Herschel," writes Arago, "used to say that when the atmosphere is laden with dampness the images of the heavenly bodies have a remarkable sharpness. This sharpness also exists during a hazy sky, leaving to the telescopic images all the neatness of their outlines."[1] Webb, too, remarks that "a hazy or foggy night sometimes defines bright objects admirably"[2]; while Asaph Hall, using the 26-inch Washington refractor, often wrote sentences like these: "A very fine image of Saturn through fog", allowing the use of powers of 605 and 888.[3]

As it is stated on p. 68 that the brunt of this discussion falls on the work done at the Lowell Observatory, I wish to define my attitude clearly on this point. I have nothing but praise for the fine creative spectrographic work of the Director, Mr. V. M. Slipher; for the admirable photographs, including discoveries, of Mr. Lampland, that distinguished pioneer in Martian photography[4]; and for the infinitely interesting discovery of Pluto by Mr. Tombaugh. And, although that discovery is the product of a lucky coincidence, yet I think that Mr. Tombaugh was not sufficiently rewarded by the astronomical societies for his feat. Without Lowell, the existence of Pluto would remain unknown; and this discovery, considered with others made at Flagstaff, does much more than atone for the general canalization of the planets and similar tales of wonders.

The quotation from Mr. W. H. Pickering, that Meudon is situated in the anti-cyclone belt, never yielding fine definition, is unfortunate, as the same Mr. Pickering wrote that in 1924, during the "test of giant telescopes, . . . Meudon came off best, and detected the most fine detail."[5] On the doubtful assumption that such conflicting statements can really have a meaning, then astron-

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[1] *Vie d'Herschel*, p. 290.

[2] *Celestial Objects*, 4th ed., p. 16.

[3] *Saturn and its System*, p. 10.

[4] I had given justice to Mr. Lampland in my book, p. 62, as well as in *Popular Astronomy*, vol. 33, 1925, pp. 659-660.

[5] *Popular Astronomy*, vol. 34, 1926, p. 303.

omers may fearlessly locate their instruments in a bad station, with poor seeing, in order to see the finest detail on Mars.

I have generously conceded in my book that Flagstaff, at 7,250 feet above sea level, is the best observing station for all-year-round work. The Pic du Midi, in France, at 8,650 feet, is still better, although work in winter has not hitherto been possible there. Yet the vicinity of the great San Francisco Peak must occasionally reduce the excellence of the seeing at Flagstaff; and it must have been this fact that prompted Prof. Barnard to write to me on 1910, May 27, that "the work of Mr. Burnham and Prof. Aitken with the 36-in. Lick shows measures of double stars so close that Mr. Lowell's telescope and atmosphere could never reach them."

It is a well-known fact that *any* locality *does* yield occasionally perfect definition. This year, I saw Mars without a quiver in the smoke of Paris with a 10-inch refractor; and, in 1891, the eminent English observer, Denning, wrote that he "frequently found planetary markings very sharp and steady through the smoke and fog of Bristol."[6]

The slight superiority of Flagstaff over other stations lies in a greater transparency of air (which is no advantage on the planets), and in a larger proportion of nights yielding excellent definition. But it is a great mistake to believe that wonders can be accomplished there by stopping down aperture, or that Lowell and his assistants on Mars were infallible. The canals discovered at Flagstaff on all the planets known to the ancients and on the IIIrd satellite of Jupiter have been pronounced illusive by one of their most energetic discoverers, by Mr. A. E. Douglass, who had drawn hundreds of them during his long collaboration at Flagstaff with Lowell.[7] We can thus easily understand that a discrete veil of oblivion has been cast, and is still being held, over that momentous declaration.

It is also in the fine air of Flagstaff that a spurious satellite to Sirius was discovered and measured by several observers. Between 1894 and 1896, engineers must have been very plentiful on Mars,

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[6] *Telescopic Work for Starlight Evenings*, p. 81.

[7] "Illusions of Vision and the Canals of Mars", in *Popular Science Monthly*, vol. 70, 1907, pp. 464-474.

and busily engaged, too, in filling up old canals and digging new ones, and this to the extent of myriads of miles over the pink desert expanses of the planet.

With regard to the spoke-like markings discovered by Lowell on Venus, which were as distinct as the spots on the moon, I wrote in 1898 that, to believe in their reality meant "to believe that the globe of Venus, with its atmosphere, is imprisoned in a cage of black hoops meeting about a common diameter directed along the visual ray", and that, consequently, these linear markings were illusive.[8] This meant that Venus seemed to present always the same face, not to the Sun, but to Flagstaff; and, in 1902, Lowell found that "the centre of the (spoke) system shifted, not in accordance with the rotation of the planet, but so as to keep that centre in the centre of the disc."[9] Here we have an unconditional surrender to my views. But what a demonstration of the fact that excellence of seeing in the best of stations is no safeguard against illusion!

It is stated on page 71 that "anyone with the slightest experience in photography knows that improved definition results from stopping down". But the writer of the article under discussion is ignorant of the fact that such stopping is only necessary in order to bring to focus neighbouring terrestrial objects as well as distant ones! It is his ignorance of the existence of diffraction that prompts him to question the fact that the planet appears nearer in large apertures. The complex details of Mars, which are blended into confused masses in telescopes under 15 inches, are separated into their chief components and become irregular in a 33-inch through the reduction in size of all bright spots and areas. The distinguished American astronomer, C. A. Young, thus aptly remarked that diffraction "has much to do with the superiority of large instruments in showing minute details. No increase of magnifying power on a small telescope can exhibit things as sharply as the same power on a large one."[10] In a letter dated 1910, Jan. 3, Prof. Hale fully endorses this statement: "I have always found that under the best atmospheric conditions an aperture of 44 inches, or even more, is highly advan-

[8] *Monthly Notices of the Royal Astronomical Society*, vol. 58, p. 316.
[9] *Journal of the British Astronomical Association*, vol. 13, p. 13.
[10] *General Astronomy*, rev. ed., p. 16.

tageous for the study of planetary details." As for focal length, the 53 feet of the refractor I am using are quite satisfactory.

A tremendous quintuple error, implying irresponsibility, appears on page 68, where it is stated that when I was observing Mars from "1909 to 1916 and 1924 to 1929", the planet "was south of the equator", and "too near the horizon . . . for the seeing to be good". Now, at the 1911 opposition, Mars was in north declination 21°44′; in 1914, at 26°33′ north; in 1916, at 19°3′ north; in 1926, at 14°28′ north; and in 1928, at 26°38′ north. Hence the planet southed here during these oppositions, at the great altitudes of 55°40′ to 67°50′ above the horizon, and, twice, even above the culminating point of the ecliptic in the northern hemisphere of the heavens!

It is on a drawing by Mr. E. C. Slipher, sent to me by Lowell in 1910, that I noticed the representation of linear canals defying perspective; and as to the similar canals disobeying perspective by Mr. Trumpler, a child will instinctively recognize them at a glance on his published drawings.[11]

The writer of the article under discussion next quotes a passage from Lowell, stating that in the experiments conducted by Flammarion with boys on artificial discs having dots and shades, "not a boy then drew an illusory line". But this is also wrong, since Flammarion distinctly writes that "three pupils drew a line on the edge of a shading".[12] Hence the accusation of my not mentioning the test of Flammarion turns against my contradictor like his other unguarded statements, all of the boomerang type.

The insinuation that Maunder instructed the Greenwich boys to draw canals is highly disingenuous. All those who knew that most gifted English astronomer were struck, not only by his genius, but also by his infinite honesty and straightforwardness.

Since the question of my drawings is raised on page 71, I will give passages of three letters addressed to me: "Mars would certainly be pleased with his portraits", wrote Lowell in 1897, March 5, "could he see himself as you depict him". And "the very remarkable correspondence or agreement," wrote Prof. Barnard on

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[11] *Popular Astronomy*, vol. 34, pl. IV, opposite p. 156, fig. 16, 20 and 24.
[12] *Bulletin de la Société astronomique de France*, vol. 33, pp. 659-660.

1913, May 16, "of your drawing of the Syrtis Major with Prof. Hale's beautiful photograph ought to be of interest to every one interested in Mars. It shows how accurate your drawings are". Prof. Barnard also write to me on 1911, Oct. 15: "You have made great progress in adjusting the vexed question of the canals. You have a wonderful advantage in your skill as an artist. The trouble often with observers is that they cannot faithfully represent what they see". I have proved in 1915 that the drawings of Lowell, which too often do not show conspicuous details,[13] are controverted by his own photographs; and that these photographs have confirmed only my own delineations of the planet.[14]

An observer in Jamaica ventured to predict physical phenomena on Mars; but the planet belied these predictions while responding to mine.

Mr. E. C. Slipher is quoted on page 71 as having shown that I had drawn too large the south polar cap of Mars in 1924. But, in my reply to the Flagstaff observer, I could demonstrate that my dimensions of the cap were confirmed at the time visually by Mr. Hamilton and photographically at Mount Wilson, and also that, in order to prop up his contention, Mr. Slipher was obliged to print his photographs so dark as to reduce the size of the cap down to extinction![15]

I have submitted the precious photographs of Mr. Lampland, of Prof. Barnard, and of Prof. Hale to a very close examination, and can affirm that they reveal no geometrical network of canals, but only real, broad and diffused streaks and faint half-tones in the continental regions of the planet. Some alinements of grain on the Arizona positives give, here and there, the impression of narrower bands on one image; while other alinements yield other streaks on another image. Very often, such alinements do not correspond to genuine irregular streaks on Mars; and Schiaparelli himself expressed doubts on their reality. Lastly, there is a contradiction

[13]Thus, in 1909, Lowell missed visually Mœris Lacus, which subtended 4″ (the diameter of Uranus), while that lake was then prominent on the roughest photographs of the planet.

[14]*Memoirs of the British Astronomical Association*, vol. 20, p. 33.

[15]*Popular Astronomy*, vol. 33, pp. 659-660.

in the statements of Mr. E. C. Slipher on page 73, since he is represented as saying that his photographs have confirmed the majority and at the same time the totality of his visual observations. Yet, notwithstanding these conflicting declarations, we have never seen, and will never see, recorded by the sensitive plate, the geometrical network of canals, pumping stations, and vegetation bands, those wonderful productions of the genius of the Martian engineers.

The serious, painstaking observer, who scrutinizes the planet for hours together on every cloudless night, is liable to catch glimpses of dark lines, each glimpse lasting, according to my experience, about one-seventh of a second. This is particularly the case with medium-sized instruments. Such glimpses of lines constitute the canals; but as they disappear under the sharper definition of large telescopes, they are manifestly illusive. In September, 1909, I called attention to the fact that I could see no canals in the 33-inch while holding steadily much more delicate detail than ever drawn by Schiaparelli and Lowell. Hence the geometrical network of canals on Mars was proved illusive 24 years ago.

The reason of the scientific world has been too often insulted by the awful representation of canals defying perspective. It is, indeed, incredible that such illusions could really be foisted on the public. Nor will the artful attempt to disconnect the superiority of large telescopes on double stars from their definition of planetary detail have any hope of success. Owing to diffraction, a real dark line is much better seen under the superior separating power of a large aperture. Now, it so happens that there *is* precisely a real dark line on a planet; a line whose existence no tyro, no visionary, ever tried to question. This is Cassini's division in the ring of Saturn,—a line which is very narrow in a 6-inch, less narrow in a 10-inch, and which becomes broad like a dark zone in a 33-inch. These are the appearances which the linear canals of Mars ought to present if they were real; but, instead of increasing in breadth and conspicuousness with aperture, they vanish! Why? Because they are unreal and illusive; and this argument constitutes an unanswerable confutation of the whole canal fallacy.

Prof. Ritchey, who is by far the greatest optician of all time,

and who has revealed the true structure of the visible universe, repeatedly assured me in 1928 that, having carefully scrutinized Mars with the most powerful 60-inch reflector of Mount Wilson, constructed by himself, he could never see a single linear canal, or network, on the surface of the planet, although grasping minute detail beyond the range of the largest refractors in existence. When, therefore, a believer in canals invokes that great American astronomer, he is wielding most undexterously the weapons of controversy.

The outcome of this discussion is thus clear to all: it is diametrically opposed to the fond hopes entertained by the amateur who has so imprudently provoked it; and the alleged canal network of Mars, pronounced illusive by one of its most prolific discoverers at Flagstaff, vanishing when it ought to be most conspicuous, and further transcending natural law by defying perspective and diffraction, moulders into dust as a vain delusion of the past.

Paris, 1933, June 28.

THE PACIFIC SCIENCE CONGRESS

By W. E. Harper

IN a radio talk given over CFCT, Victoria, B.C., on May 9th, 1930, a summary of which was printed in the October, 1930, issue of this Journal, the writer outlined the aims and objects of the above Congress and summarized the proceedings of the previous four Congresses held respectively in Honolulu, Australia, Japan and Java.

By invitation of the Government of Canada and under the auspices of the National Research Council, the Fifth Pacific Science Congress opened its sessions in Victoria on June 1st and concluded them in Vancouver on the 14th. Four days were spent in Victoria and ten in Vancouver, following which a post-Congress tour of the province was made, ending at Field after five days enjoyment of wonderful lake and mountain scenery with an inspection of some of the large industrial plants of the Province thrown in for good measure.

The aims of the Congress in brief are two: (1) to study all problems connected with the Pacific and the countries bordering thereon, and (2) through such co-operative study to create a spirit of goodwill among all the peoples having interests in the Pacific. The Congress was originally planned for a year ago but the economic situation rendered postponement for a year adivsable. There was some doubt as to its being held even this year, but owing to foreign commitments and arrangements already made further postponement was not advisable. Invitations were extended to some thirty countries bordering on the Pacific and representatives were present from almost all. New Zealand was not represented but delegates were present from Australia, China, Japan, Java, Philippine Islands, France, the Netherlands and the United States, to give only a partial list. Almost all spoke English, the official language of the Congress, but naturally it was sometimes difficult in technical papers to grasp all that was said by foreign delegates. Japan was well represented by fifteen scientists and it was noteworthy how meticulously careful they were in the matter of dress

for the various social functions connected with the Congress. The Japanese are, however, mild of speech and usually in the larger gatherings much of what they said could be heard only with great difficulty. The loud-speakers employed on several occasions, such as for luncheon addresses, could with profit have been used on other occasions as well.

At the opening ceremonies, after the Lieutenant-Governor had extended a welcome, various selected delegates voiced the greetings of their respective countries. The Provincial Government tendered a luncheon the first day, at which Premier Tolmie presided. One could not feel but that the provision of liquors was quite unnecessary. The civic luncheon followed on the second day with Mayor Leeming as toastmaster and the Principal of the High School, Mr. Ira Dilworth, bringing a message from the educationalists of the province to the visiting scientists. The choice of the speaker was unique but a happy one. The mayor's plea for our visitors to become boosters of our tourist trade we feel might have been more effective if less direct, but the kind reception accorded all delegates no doubt will bear fruit in days to come in the tourist traffic which the mayor and others have so much at heart.

The weather in Victoria was on its very best behaviour. The squally weather of the closing days of May had given place to sunny skies when the Congress opened on June 1st. When the visitors left on Sunday, the 4th, the weather felt it could again relax and dull, raw days ensued. One felt sorry for Vancouver, which seemed fated to experience such dismal weather just when everyone could have desired a continuance of the glorious days they had been experiencing before the arrival of the overseas delegates.

The members were delighted with the beautiful view from Observatory Hill on the afternoon of the first day, after which they visited the world-famed gardens of Mr. and Mrs. R. P. Butchart. Several returned at night to the observatory, where we kept open house so they might behold the beauties of Jupiter and the Moon. The starry night with the half moon, Jupiter and Mars in close grouping, coupled with the electrical illumination of the city and that of Port Angeles, across the Straits, made a never-to-be-forgotten impression on the visitors.

The meetings at Victoria concluded with the Congress banquet on Saturday evening, June 3rd, following the garden party at Government House earlier in the afternoon. On Sunday morning the delegates left by the "Princess Louise" for Vancouver, going first to Nanaimo, from which place side trips were made to Cathedral Grove at Cameron Lake (where the big timber is), and to the Marine Biological Station near Nanaimo.

The Congress was divided into two main divisions, namely, (1) Biological Sciences, and (2) Physical Sciences. Each of these was further sub-divided into Sections with a Chairman for each, who was appointed three years ago. In the Division of Physical Sciences which most concerns readers of this JOURNAL, were the following seven sections with their respective Chairmen: 1. Astronomy—Plaskett; 2. Geodesy and Geography—Ogilvie; 3. Geology and Mineral Resources — Schofield; 4. Oceanography — Fraser; 5. Meteorology and Terrestrial Magnetism—Patterson; 6. Radio—Eve, and 7. Seismology and Volcanology—Hodgson.

Five combined meetings at which all sections were supposed to participate, were held. These Congress symposia, as they were designated, had as their general theme the relation of science to the four basic industries of the province—mining, forestry, agriculture and fishing. The one relating to forestry was held at Victoria, the remainder at Vancouver. Then divisional symposia, in which the seven sections of the Physical Sciences formed one group, whilst the eight in the Biological Sciences formed another, were also held. Lastly, the fifteen sections in separate meetings considered matters of importance only to their respective groups. The writer attended the Vancouver meetings only on Monday, the 5th, and Tuesday, the 6th, and had, therefore, a limited experience of how the arrangements functioned. It would seem to him that the divisional symposia were not the success that might have been achieved, but this was offset by a very elastic arrangement permitting joint-sectional meetings where the interests of the participating members were much more in common. As an example of such, one could cite the two joint meetings held by the three Sections, Astronomy, Meteorology and Terrestrial Magnetism, and Radio.

At the first of these there were four papers presented. (1)

Adams, director of the Mt. Wilson Observatory, gave a comprehensive summary of our knowledge of the Sun as a Variable Star. (2) Abbot reviewed the Smithsonian Researches on Solar Radiation (paper read in his absence by the writer). (3) Patterson presented a paper by Jackson on Solar Activity and Terrestrial Magnetism. (4) Pettit prepared a splendid paper on Ultraviolet Solar Radiation. At the second meeting Plaskett presented Stetson's paper on Radio Reception and the Sun Spot Cycle. Beals gave one on the Audibility of the Aurora and its Appearance at Low Levels. Much discussion took place on all the papers. Then in a very masterly and lucid style Eve brought to our notice all the recent developments in radio and the theories regarding the propagation of wireless waves. One was just a little thrilled to learn that amateurs had been sending messages across the Atlantic, using a power of only 60 watts, such as is employed in an ordinary electric light bulb.

Possibly the biggest thrill was when at 10 o'clock in the morning of June 5th in the Vancouver Hotel ballroom, an address was given from Cambridge, England, by Lord Rutherford, formerly of McGill University. Following his address, which came over clearly, conversation was carried on with him by Dr. Tory, the President of the Congress, by Hon. H. H. Stevens, and principally by Dr. Eve of McGill, who was a former colleague of Rutherford. The snappy questions and immediate replies were much enjoyed, the more so as the personal element was so much in evidence. It gave a vision of world communication on a wholesale scale, though simpler arrangements will yet have to be effected before the average person can afford such a means of communication. I understand an equipment worth sixty millions was involved in the broadcast.

In the matter of hospitality, Vancouver tried to outshine even Victoria. Luncheons by the Board of Trade, the Kiwanis and Rotary Clubs, the Canadian Club and that given by the citizens generally were much enjoyed by members of the Congress. Trips were arranged also to various points of interest, including one to Grouse Mountain, where dinner was served in the Chalet amid winter conditions, there being six feet of snow outside.

Following the Congress dinner on the concluding day of the

Congress, June 14th, the members entrained for the special post-Congress tour. The route lay by the Kettle Valley Line through the Okanagan, it being planned to use the motor busses through the scenic part of the mountains and terminate the tour in Calgary on the 19th. A landslide changed the plans somewhat, necessitating travelling via the Crow's Nest Railway route to McLeod, thence north to Calgary, thence west to Banff, after a comfortable rest at the Palliser Hotel in Calgary. From Banff the motor busses were used, visiting Lake Louise, Emerald Lake and the Yoho Valley, the tour ending at Field.

Inspection was made en route of the large smelting and refining plant at Trail, B.C., the largest by far in the world. The ore comes from the Sullivan mine at Kimberley, as much as possible of the iron ore being extracted at the mine to avoid haulage charges to the smelter. Here the lead and zinc are deposited electrolytically on thin aluminum sheets, the output being several hundred tons per day (if memory has not played false).

Over the line from the smelter to the mines at Kimberley nothing but freight trains, of course, are the rule, and a palatial train like the one provided by the C.P.R. for the members of Congress was, naturally, an attraction to the inhabitants along the way. On arrival at Kimberley the delegates as they alighted from the train were mildly surprised to find apparently the whole population of the children crowding around the train. They took it as a compliment to themselves that they were the attraction, but the real reason, according to the local school teacher, for the children being on the spot, was not to see the scientists but the darky porters whom they had read about but never witnessed in the fleseh. (The story was told the writer by a certain dignified professor in one of our Canadian Universities and he has a reputation for veracity. I shall let it go at that.)

These rambling notes do not aim to "cover" the Congress, but only to present some sidelights. It was not the writer's privilege to be able to take much part in the Congress.

THE COUNTERGLOW*

By E. G. Hogg

THE counterglow, or in German, gegenschein, is a faint patch of nebulous light, roughly in the shape of a circle whose centre is in that part of the sky which is exactly opposite the sun's place. The illuminated area appears visually to have a diameter ranging from 7 to 10 degrees, but when measured with a photo-electric photometer is found to extend considerably beyond this limit.

It was first noticed by Brorsen in 1855, but for 30 years few observations were made and discussed, with the result that very little was known about it. It was rediscovered by Backhouse in 1868, and again in 1883 by Barnard, to whom we owe most of our information on the subject.

The counterglow is not an easy object to visualise, requiring not only a clear, moonless night, but also good sight. As its position in the sky is opposite that of the sun at the time the observer is seeking it, one should have little difficulty in knowing generally where to look for it. The best time for observation is midnight, when it will be on the meridian, but it can be seen as early as 10 p.m. Barnard states that it can be most easily picked up by looking directly at the expected site of the phenomenon, then turning the eyes about 60 degrees to the west without moving the head and then letting the eyes slowly travel back to their first position. "There must be no moonlight; the sky must be clear and not hazy; there must be no artificial light near to blind one; above all, do not look for a small, difficult object; it is like a large spot of haze, almost conspicuous when best seen." These are Barnard's injunctions, and by carrying them out carefully some readers may be rewarded by seeing this interesting phenomenon.
phenomenon.

Recent Work on the Counterglow

In the January issue of the "Astrophysical Journal" Mr. C. T. Elvey describes some recent observations on the intensity of illumination of the counterglow made with a photo-electric photometer

*In "Astronomical Notes" of the New Zealand Astronomical Society.

attached to the 40-inch refractor of the Yerkes Observatory. It may be premised that the light coming to us from the region of the counterglow is made up of two parts, that due to the glow itself and that scattered in the atmosphere lying between us and the glow. By a series of observations taken outside the area of the glow Mr. Elvey measured the intensity of this scattered light, and then, directing his instrument on the glow, measured the combined light reaching him, and was therefore able to estimate what was the intensity of the light from the glow itself.

Mr. Elvey's observations were taken on three nights—September 25 and 28 and October 1 last,—and during this short period of time considerable changes were noticed in the glow. When first measured it was nearly circular in shape, its centre was about two degrees behind the anti-sun or point in the heavens diametrically opposite to the sun, the intensity near the centre was equivalent to that of a star of photographic magnitude 6.54, and the total light emitted was equal to that of a star of magnitude 0.52. By the second night it had become elongated along the ecliptic, the mean intensity at the centre was equal to that of a star of photographic magnitude 6.51, while the total light now equalled that of a star of magnitude −0.06. When last measured (October 1) it was "egg-shaped," with the longer axis along the ecliptic, the centre was definitely ahead of the anti-sun in longitude, the central intensity was that of a star of magnitude 6.22, and the total light had risen to equality with that of a star of magnitude −0.28. Mr. Elvey does not suggest any explanation of these progressive changes in the size and brightness of the glow observed during his brief study of it.

The Origin of the Counterglow

Various attempts have been made to account for the cause of the counterglow or gegenschein, but it cannot be said that any hypothesis has yet been put forward which commands general assent. Barnard writes: "The gegenschein has always seemed to me to be due in some way to a concentration of the sun's light by refraction in the atmosphere (opposite the sun), as if the atmosphere acted as a spherical lens." And again: "When well seen, the gegenschein does not seem to be extremely far away; indeed, it

always appears to me to be an illumination of our own atmosphere and not a distinct celestial body." Barnard, however, finds two strong objections to this theory; if the bright region is comparatively close to us (as it must be if it is within our atmosphere), then the star which marks its centre for one observer will not be the same for an observer in another part of the earth, as the two will see it against different backgrounds of stars. This, however, does not appear to be the case; the centre is marked by the same star for all localities when it is visible at the same time. Furthermore, Barnard has numerous observations on record when the illuminated area is not circular, but elliptical in shape, an appearance which it is difficult to account for, as an effect of refraction of the solar light in the earth's atmosphere.

There is good reason to believe that in the space beyond our atmosphere is a vast amount of fine meteoric matter revolving about the sun; estimates may differ as to the amount of such matter trapped by our atmosphere during the course of the year but all are agreed that it is very considerable and therefore it is difficult to escape the inference that finely diffused matter exists in great quantity in inter-planetary space. These particles would be capable of reflecting the sunlight falling on them and it may be, as Searle suggests, that those which are in the direction of the anti-sun and therefore in what we may call the full-moon stage reflect back more light than those lying in other directions, and so by their greater brightness cause the illumination we call the counterglow. Moulton is of opinion that there would be a concentration of these particles, under the combined attraction of the sun and earth, in the neighbourhood of a point on the line through the two bodies, and about a million miles outside the earth's orbit. It is probable that both factors contribute to the observed effect.

In connection with this question of reflecting particles, we may quote the following interesting passage from "Astronomy," by Russell, Dugan, and Stewart: "The quantity of reflecting matter required to produce the observed illumination of the sky is surprisingly small. Calculation shows that it would be accounted for if, inside the earth's orbit, there were particles one millimetre in diameter, of the low albedo of the moon and at an average distance

of five miles apart; of if, in case the light is scattered by molecules of gas, the whole amount of gas in the thickness of nearly 200 million miles would, if compressed to atmospheric pressure, form a layer one centimetre thick.

"So rare a medium would be without sensible retarding effect on the motion of planets or comets traversing it, and the attraction of the whole mass, even on the most extreme reasonable assumptions, would be far too small to produce any sensible effect upon the motion of the planets."

NEWS AND COMMENTS

GENERAL

Dr. V. M. Slipher, Director of the Lowell Observatory, Flagstaff, Arizona, who was presented this year with the Gold Medal of the Royal Astronomical Society, delivered the George Darwin Lecture at the meeting of the Society on May 12, on the subject, "Spectrographic Studies of the Planets".

Professor S. A. Mitchell, Director of the Leander McCormick Observatory of the University of Virginia, has been elected a Foreign Associate of the Royal Astronomical Society.

Dr. Frank Schlesinger, Director of the Yale University Observatory, has been elected a correspondent of the Paris Academy of Sciences.

Professor H. H. Plaskett delivered his inaugural address as Savilian Professor of Astronomy at the University of Oxford, on April 28, on the subject, "The Place of Observation in Astronomy".

Professor Einstein has accepted a chair of mathematical physics in the Collège de France, created by special legislation of the French Government.

The McDonald Observatory of the University of Texas and the University of Chicago, as announced by Dr. Otto Struve, Director of the Yerkes Observatory, will be located on Mount Locke in the Davis Mountains in southwestern Texas. At latitude 31° and elevation about 6,800 feet, with excellent observing conditions, the 80-inch reflecting telescope will be a very powerful addition to the equipment of astronomers.

NOTES FROM THE DOMINION OBSERVATORY

At the weekly meetings of the staff of the observatory, during the 1932-1933 term, the following subjects or reviews of published papers were presented and discussed:

Nov. 30, R. Meldrum Stewart, "The Study of the solar corona without eclipse"; Dec. 7, M. M. Thomson, "Comparison between time signals observed by coincidence and those recorded automatically"; Dec. 14, C. R. Westland, "Variation in the solar rotation"; Dec. 21, E. A. Hodgson, "Experiments testing seismographic methods for determining crustal structure"; Jan. 4, A. H. Miller, "The effect of the sun and moon on gravity"; Jan. 11, C. A. French, "The solar diurnal variation of the magnetic declination"; Jan. 18, F. Henroteau, "Photoelectric cells"; Jan. 25, J. P. Henderson, "Heaviside layer measurements"; Feb. 8, R. E. DeLury, "Characteristic features of solar prominences"; Feb. 15, R. M. Motherwell, "The international cepheid programme"; Feb. 22, R. Meldrum Stewart, "Meteor craters"; Mar. 1, W. W. Doxsee, "Deep-seated earthquakes"; Mar. 8, R. J. McDiarmid, "Tides in the atmosphere"; Mar. 15, R. G. Madill, "Principal facts of the earth's mganetism"; Mar. 22, A. H. Miller, "Isostasy in India"; Mar. 29, Miss M. S. Burland, "The Moll microphotometer, its operation and applications"; Apr. 5, J. P. Henderson, "The eclipse-test of ionization by corpuscles"; Apr. 13, J. L. O'Connor, "Sunspots and tree-growths"; Apr. 26, R. Meldrum Stewart, "The rotation of the galaxy"; May 3, S. Gold, "Reflected and refracted seismic waves due to an incident compressional wave"; May 6, C. A. French, "Permanency of magnetic moments of magnets in magnetometers"; and on May 26, Dr. J. A. Pearce of the Dominion Astrophysical Observatory gave an account of "Some recent investigations at the Victoria Observatory".

Dr. Ernest A. Hodgson, Chairman of the Section of Seismology and Volcanology of the Fifth Pacific Science Congress, has returned to the observatory from the meetings of the Congress held in British Columbia, June 1-19. He reports a most successful meeting, the attendance being better than had been anticipated and well representing the circum-Pacific countries. The programme was well rounded and the discussions particularly valuable.

Mr. A. H. Miller left the observatory on July 6, for Grand Rapids on the Mattagami River, near Moose Factory, to continue his investigations begun in 1931, with the torsion balance and

magnetometer, of the siderite deposit, in co-operation with the Ontario Research Foundation and the Ontario Department of Mines. He will be absent two and a half months.

The observatory is planning to take part again in the international longitude observations during October and November, by observing at Ottawa and Vancouver. A Cooke 3-inch transit has been converted into the broken type; and Mr. C. C. Smith has designed personal equation instruments for the absolute determination of personal equation, and these are now being constructed.

REDeL.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Seeing the Southern Cross.

Nearly every traveller to the south is anxious to learn when he will first be able to see the Southern Cross. Of course, he must know also the time of the day, at the season he is travelling, when the stars are on the meridian.

Recently in a book entitled "Spanish Sunshine", by Eleanor Elsner (N.Y., 1925), I came across the following sentence (page 14) in the description of the town of Malaga:

> At a particular time in the year the highest stars of the Southern Cross can be seen from the cathedral tower, the only place in Europe from which they are visible.

This broad definite statement challenged attention. The latitude of Malaga is about 36° 43′, that of Cadiz is 36° 31′, and that of the most southerly tip of Spain is 36°, while the island of Crete extends a degree still farther south. Hence these portions of Europe are more favourable for observing the southern constellations. I could not find the height of the cathedral tower to learn how much it would add, but if it were 400 feet the dip of the horizon would be one-third of a degree, that is, one could see one-third of a degree farther south of the celestial equator.

On examining the conditions more closely I found that the declination of Gamma Crucis, the farthest north of the four stars of the Cross, is 56° 44′ S., and to see this star when it is on the meridian the greatest north latitude on which one should be is 33° 16′. Refraction would add to this about 34′, making it 33° 50′, which is nearly 3° south of Malaga. I am afraid the author did not by actual observation verify her statement.

Luminous Night Clouds.

A brief account of these remarkable objects, with three illustrations, was given in our issue of December, 1932 (Vol. 26, p. 437).

Further information has just been received. It is in Publication No. 6 of the University Observatory, Oslo, and is supplied by Professor Carl Störmer, who is well known for his pioneering investigations into the height and the nature of the aurora.

About forty years ago O. Jesse, of Berlin, gave a summary of his measurements of the height of these noctilucent clouds made from 1885 to 1891.

These clouds are like cirrus but are of a shining blue-white silvery colour, and appear some hours after sunset or before sunrise. They have a wave-like formation. Their appearance relative to the sun indicates a very great altitude and this is confirmed by actual measurement. Jesse found the heights to vary from 80 to 89 km., the average being 82 km. above the surface of the earth. He also determined the velocity of the clouds and found it to range between 100 and 300 metres per second, though sometimes less than this.

Professor Störmer has a chain of stations in southern Norway to assist him in securing simultaneous photographs of the aurora, and when these luminous clouds appeared during the summer of 1932 he called up his helpers and the desired photographs were obtained on the nights of 10-11 and 24-25 July. From 7 pairs of good plates 37 heights of prominent points of the clouds were measured. They gave heights between 74 and 92 km., the mean of all being 81.4. The clouds were found to move from NNE with a velocity between 44 and 55 metres per second. The sun's rays which illuminated the clouds did not pass nearer than 30 km. from the earth's surface and thus did not traverse the troposphere or lower layer of the atmosphere. From measurements of a series of parallel cloud waves on July 24-25 the mean distance between consecutive crests was found to be 9 km., which also agreed with Jesse's results. The spectrum of the clouds resembles on the whole that of daylight.

Unpublished Observations of Variable Stars.

The publication of long series of observations of variable stars, at present preserved in various observatories and private libraries, will be of very great importance for the study of the modifications

of the periods of the variable stars. It will also facilitate the study of the changes of the light curves, of the colour, and of the amplitude of variation of these stars. The present economic conditions render impossible at the present time the detailed publication of the numerous series of unpublished observations on hand. But the publication of a summary of this material will not be a very great expense. Professor Shapley, then president of the Commission of Variable Stars of the International Astronomical Union, suggested to the meeting at Cambridge in 1932, the preparation and the publication at the expense of the Union of a list of all the unpublished observations. This proposal was accepted by the Union and Mr. H. Grouiller, astronomer at the Lyons Observatory, was asked to undertake the preparation of this list.

All persons having such unpublished observations in their possession are asked to inform Mr. Grouiller and to send to him a table showing the condition of the variable stars for which they have these observations, and, for each star, the number of observations per year and the method of observation utilized. It will also be important to state on what conditions these observations can be communicated or how a transcription can be obtained. All complimentary information will be very welcome.

The list of all these unpublished observations will be of the highest use to persons engaged in researches on variable stars; only thus can all work done on a star be provided as a foundation for a complete monographic study.

Please address replies to Mr. H. Grouiller, Astronomer at the Lyons Observatory, St.-Genis-Laval (Rhône), France.—*Official Communication from the Commission on Variable Stars of the International Astronomical Union.*

A New Zeiss Catalogue.

A catalogue of scientific instruments may be quite as interesting and useful as a text-book. This remark is true of a new catalogue from Carl Zeiss, designated Astro 516e. It contains 88 pages and is profusely illustrated.

As is stated in the "Foreword", astronomical instruments are usually designed in accordance with the purchaser's wishes, and thus

the manufacturer, in the course of time, becomes possessed of many ideas contributed by the men who actually use the instruments. The present book shows a selection of the equipment supplied by this firm during the past thirty years.

It is not possible to draw attention to the numerous peculiar features shown in the catalogue. One is the special weight-stress compensation system used in many mountings. The observation platform for the 24-inch reflector of the National Research Institute of Astronomy at Nanking is surely unique. It is of the tilting type, is revolvable to any position around the instrument and the platform proper is vertically adjustable. Another novelty is a twin eye-piece for two observers, such as an instructor and his student. The last seven pictures are of Zeiss planetariums. They include those at Los Angeles, Philadelphia and Moscow, the last being very modernistic in appearance with a beehive-shaped dome.

C.A.C.

MEETINGS OF THE SOCIETY

AT OTTAWA

November 25, 1932.—The Ottawa Centre held their first of a series of informal technical lectures at the Dominion Observatory. Mr. R. Meldrum Stewart was in the chair.

The speaker of the evening was Ernest A. Hodgson, Ph.D., of the Dominion Observatory and the title of his talk was "Seismology and Earth Structure Theory".

It is unnecessary to give an account of his talk, since Dr. Hodgson has since published an article in the JOURNAL for January, 1933, covering this topic.

At the close of the address there was a discussion.

January 19, 1933.—The Ottawa Centre held their second of a series of informal technical talks, at the Dominion Observatory. The president, Mr. R. Glenn Madill, was in the chair.

The speaker of the evening was Dr. D. C. Rose, of the National Research Council, and his topic was "Cosmic Rays".

An abstract of his lecture follows: "The subject was first discussed historically. The effect of Cosmic Rays was noted in the early years of the present century and was brought to the attention of physicists because of the influence on electroscopes which were used so much in the study of radiations from radio-active substances. The results of early experiments indicated the existence of a highly penetrating radiation of uncertain origin. It was not until 1913 or 1914 that the Cosmic origin of this penetrating radiation was discovered. In 1923 the first measurements of the absorption coefficient of Cosmic Rays in water were measured by Kohlhorster. They were found to be about 15 times more penetrating than the hardest gamma rays known at that time.

From this point on the subject was discussed under two heads: (1) the nature of Cosmic Rays, and (2) the source of Cosmic Rays.

1. *The Nature of Cosmic Rays.*

The nature of these penetrating rays may be either electromagnetic (photons) or particle (beta particles, protons or neutrons). A number of experiments were discussed which gave conclusions in favour of one or the other type.

Results of experiments with electroscopes are inconclusive.

Results of experiments with Wilson Expansion Chambers are interpreted by Millikan to favour Photon Cosmic Rays.

Results of experiments with Counters seem to favour the particle theory.

Results of observations on the variation of intensity with latitude and of experiments with counters and strong magnetic fields are conflicting.

On the whole the evidence of observations on the nature of Cosmic Rays appears to be insufficient to decide whether or not they are Photons or Particles.

2. The Source of Cosmic Rays.

Alternative sources are apparent. The Sun and Stars or Interstellar space.

Variations of intensity with solar and sidereal time indicate that only a small fraction if any of the total intensity comes from the sun and no measurable fraction from the stars. With a view to discussing possible sources of cosmic rays the spectral distributions given by Millikan and Regener from the analysis of absorption curves were discussed. Four components are found.

Millikan associates these with the synthesis of nuclei of helium, oxygen, silicon and iron from hydrogen atoms and electrons. Jeans' suggestion that they were due to annihilation of protons and electrons in pairs was somewhat more acceptable than Millikan's picture. These sources of cosmic rays were very speculative because of the uncertain application of the Klein Nishina formula which connects absorption coefficients with wave lengths.

Recent results indicate that the cosmic rays lose a considerable portion of their energy in nuclear disintegrations. This indicates that the Klein Nishina formula is not applicable to their absorption. Hence these interesting speculations on phenomena in interstellar space as evinced by cosmic rays have no verification and it seems hopeless to settle on their source until more is known of their nature."

At the close of his talk, Dr. Rose very kindly answered many questions, and a discussion took place.

January 27, 1933.—The Ottawa Centre held their first public lecture of the season at the Victoria Memorial Museum. The president, Mr. R. Glenn Madill, was in the chair.

The speaker of the evening was Mr. C. N. Sternberg, of the Geological Survey, his topic was "Canadian Dinosaurs". The following is an abstract of Mr. Sternberg's talk:

"Palaeontology, or the study of ancient life, is a new science when compared with astronomy and while the astronomer can predict eclipses, etc., the palaeontologist must content himself with working out the jig saw puzzle of the history of life on the earth. A study of the organic remains, preserved in the rocks, shows that each preceding age was different from each other and a careful study of these enables the palaeontologist to get a bird's eye view of the "big parade" which nature has staged across the ages.

Many families and even orders of reptiles and other animals have flourished during the past ages and then passed on, in many cases, leaving

no descendants. We would know nothing of the former existence of many of these animals were it not for the fact that they have left their bones, shells, tracks or impressions entombed in the rocks which were laid down as mud, sand or lime ooze.

Reptiles were far more numerous and important, relatively, during what the palaeontologists have called "The Age of Reptiles" than they are to-day. Dinosaurs ruled the land while aquatic reptiles ruled the sea, crocodiles and turtles inhabited the lagoons and rivers and winged reptiles flew through the air. Among the most interesting and spectacular of these ancient animals are the dinosaurs.

The first evidence of dinosaurs to be found was the discovery of their tracks found by Pliny Moody at South Hadley, Mass., in the year 1800. Young Moody referred to these as the tracks of Noah's raven. The first dinosaur's bones were described, in England, in 1824. From this small beginning we have gone forward until now more than 400 different kinds of dinosaurs are known. Forty-five of these were collected in Alberta. The dinosaurs had a world-wide distribution as shown by discovery of their fossilized bones even in Australia. Some fully adult dinosaurs were no larger than a house cat while others attained a length of over 100 feet and were the most ponderous animals which ever walked the earth. Some had long necks and very small heads while others had very large heads and short necks. Some were flesh-eaters and possessed sharp lance-like teeth whereas others had small shearing teeth and fed on plants. Some were light-limbed, slender, swift-moving creatures, while others were broad-backed, heavy-limbed, clumsy fellows, and were protected by plates of bone in the skin.

Representatives of several families of dinosaurs have been discovered in Alberta. The best known of these are the duck-billed, horned, armoured, flesh-eating and bird mimic dinosaurs. Other forms which existed at the same time are less known as they probably lived on the higher land and farther from the deltas in which the skeletons were buried.

The dinosaurs evolved so rapidly that they serve as splendid horizon markers and certain forms enable us to tell the exact age of the rocks from which they are collected.

The extinction of the dinosaurs was probably due to several causes such as the rising of the Rocky Mountains and draining off of the inland sea, the over specialization and old age of the race; the rise of the mammals and several other causes."

Mr. Sternberg's talk was illustrated throughout with lantern slides, and his moving pictures gave the audience an excellent idea of animal life years ago.

The thanks of the society were extended to the speaker by the president.

MIRIAM S. BURLAND, *Secretary-Treasurer.*

AT VICTORIA

March 31, 1933.—After the usual business and a five minute talk by W. F. Holdridge on Michelson's method of determining the speed of light, a series of astronomical moving picture films was shown. The first illustrated "How we see"; the next, "How clock time is derived from sun time". The remaining films were illustrative of some facts regarding the solar system and the nebulae. During the showing questions were answered on the subjects illustrated. As a whole, the films were disappointing.

A hearty vote of thanks was given to Mr. Arthur Hunkin for his kindness in lending and operating his projection machine for this meeting, at which about 55 were present.

April 21, 1933.—Following a most interesting talk by Lt. Comdr. Houghton, R.C.N., on "Pluto", a symposium on telescope making and adjusting was opened by W. R. Hobday.

After briefly describing with blackboard sketches the principle of the reflecting telescope and comparing the Newtonian form with the refracting telescope, Mr. Hobday described in detail the process of mirror making to the completion of the fine grinding. Mr. J. Duff then followed on figuring. Prefacing his remarks by mentioning the satisfaction of having one's own telescope and the fascination of producing by the very simple equipment necessary, an instrument whose performance would satisfy the amateur practically as well as the product of the highest professional skill, the following points were emphasized:

1. Neither a grinding and polishing machine nor delicate testing instruments are necessary nor even desirable.

2. Most of the operations are practically self-correcting.

3. Two very helpful devices due to Dr. Elihu Thomson; (a) forming the convex tool and concave mirror by grinding together two flat glass discs; (b) finding when the desired focal length of the rough-ground mirror has been reached by wetting the surface to make it reflecting and using the sun's image.

4. The polished or semi-polished surface may be tested with an eyepiece at less than focal distance. This test is more rapid and less troublesome than the Foucault test and is as delicate and informative except perhaps for the final operation of parabolising. A small error in the edge zone of an 8-inch mirror can actually be magnified 12,800 times.

5. Discs whose thickness is one-sixth of their diameter are not necessary. Mr. Duff exhibited a 6-in. mirror of almost perfect figure under moderate powers made from ¼-in. plate glass.

Both speakers stressed the necessity of cleanliness, care, and patience in all operations in mirror making.

Following these talks an interesting discussion took place which was continued informally after the meeting closed. The meeting was most successful in stimulating interest in making and using astronomical telescopes.

H. Boyd Brydon, *Secretary-Treasurer.*

The Royal Astronomical Society of Canada

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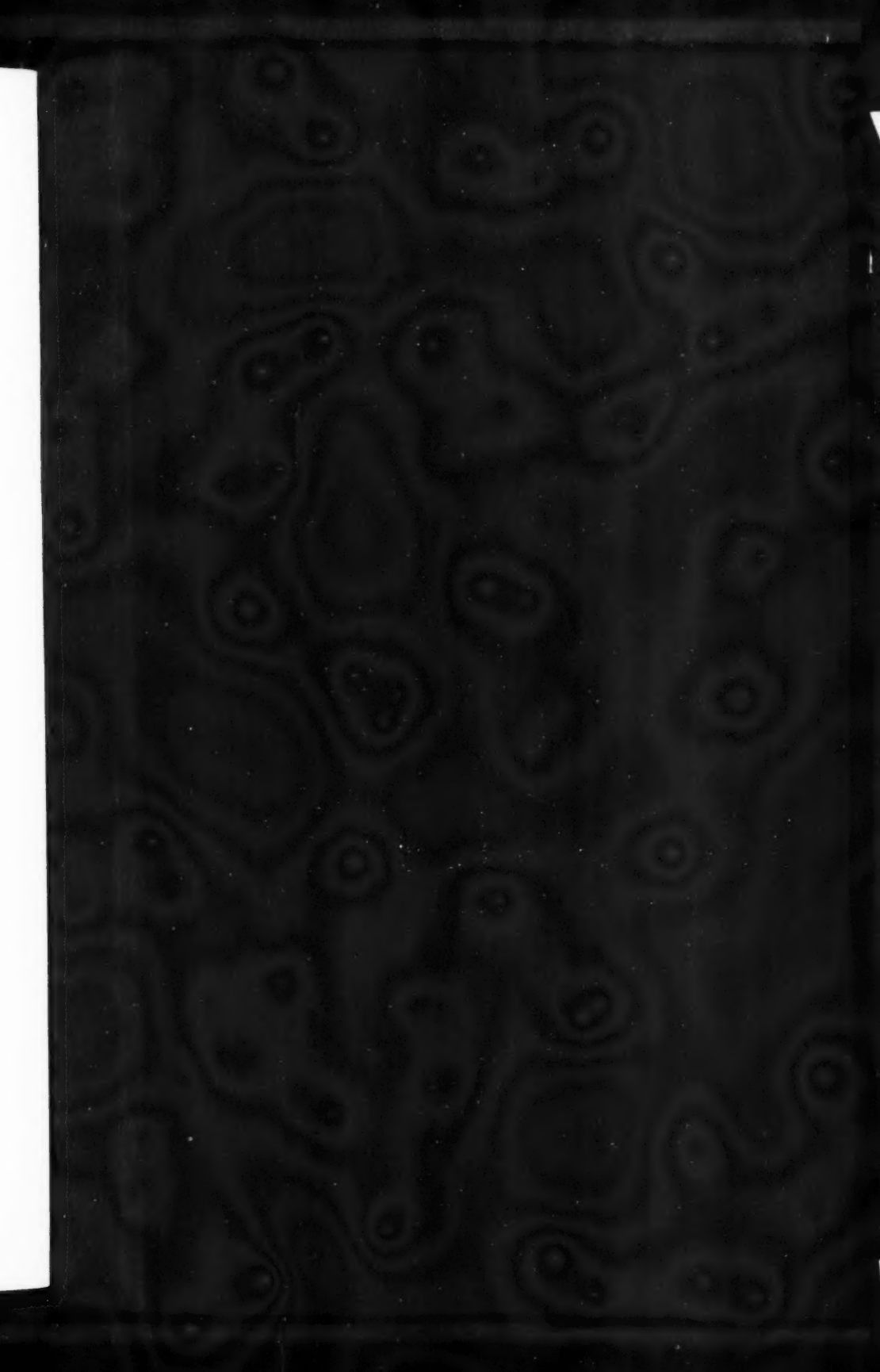
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